BRIDGING PHYSICS AND STATISTICAL LEARNING METHODOLOGIES FOR THE ACCURATE MODELING OF THE RADIATIVE PROPERTIES OF NON-UNIFORM ATMOSPHERIC PATHS - APPLICATION TO CHANNEL 7 OF EPS-SG 3MI

C. Delage[1*], F. André[1], L. Guilmard[1], M. Galtier[1], C. Cornet[2], Ph. Dubuisson[2]

[1]Univ. Lyon, CNRS, INSA Lyon, CETHIL, UMR5008, F-69621 Villeurbanne, France
[2]Univ. Lille, CNRS, UMR8518, LOA Laboratoire d'Optique Atmosphérique, F-59000 Lille, France

The objective of the present work is to describe a technique to build fast though accurate gas radiation models for application in non-uniform gaseous atmospheres. It follows recent developments, detailed in Ref. [1], where an explicit formula is provided for the solution of the implicit equation used in the ℓ-distribution approach. Statistical Learning techniques can be used to adjust the model's coefficients on non-uniform LBL transmission curves for selected Relative Air Mass factors (related to the angle between the satellite viewing angle and the ground plane surface - a value of Relative Air Mass equal to 1 corresponds to a space to ground path at Nadir). The training of the model is made using numerical methods stemming from machine learning (ADAM's optimization used in this work is from the PyTorch machine learning library). It leads to an efficient method that generalizes to a large range of Relative Air Mass. This new version of the ℓ-distribution method is called Augmented ℓ-distribution.

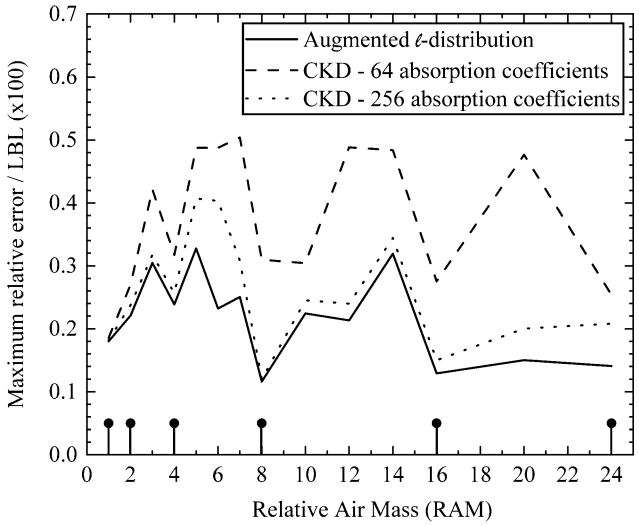

Figure 1. Comparison of Augmented ℓ-distribution with CKD models. Training data are depicted by plain circles.

Results of the method are assessed against LBL calculations in the case of Channel 7 (O_2 A-band, filter centered at 0.763 µm with a FWHM of 0.01 µm) of the 3MI instrument ([2], EPS-SG system). This channel is designed to study, among other, cloud top heights. 6 standard atmospheric profiles (Mid Latitude Summer and Winter, Subarctic Summer and Winter, Tropical and US standard) on a full atmosphere, *i.e.* over the [0,120 km] range of altitudes, are considered. Figure 1 depicts the maximum relative error, over the 6 standard profiles, as a function of the Relative Air Mass. The method outperforms usual CKD methods, by providing a high accuracy over a large range of configurations including RAM values not used in the training set, while remaining as CPU efficient as the "standard" ℓ-distribution approach.

[1] F. André, C. Delage, L. Guilmard, M. Galtier, C. Cornet, "Bridging physics and statistical learning methodologies for the accurate modeling of the radiative properties of non-uniform atmospheric paths", submitted to RAD 2023.
[2] EPS-SG Multi-Viewing Multi-Channel Multi-Polarisation Imaging (3MI) | EUMETSAT

* Corresponding Author: cindy.delage@insa-lyon.fr